The Application of Case Based Reasoning to the Interpretation of Financial Data for Acquisition Analysis

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ABSTRACT

This paper illustrates how knowledge based systems technology, and in particular case based reasoning technology, can assist in the interpretation of financial data for acquisition analysis. The authors discuss a prototype model designed to help a company formulate an effective acquisition decision. The model includes both rule based and case based reasoning technology. There is a particular focus on the issues involved in the application of case based reasoning techniques to the automation of the acquisition decision-making process. The development of this hybrid system has shown that it is possible to use knowledge based systems methods to build a hybrid decision support system in the area of financial strategic decision making, especially if the domain is well defined, has a large number of factors to be considered and the relevant knowledge is available. This system has illustrated the immense impact that knowledge based systems technology and case based reasoning can have upon business processes.

KEYWORDS

Acquisition Analysis, Knowledge Based Systems, Case Based Reasoning, Hybrid Decision Support Systems.

1. INTRODUCTION

Quantitative analysts have long used statistical methods to sift through the mass of information that is held on on-line financial databases. In the last decade advances in computer hardware and software coupled with the electronic distribution of financial databases such as Value Line [1] and Compustat [2] have enabled more sophisticated analysis to occur at the analysts' desktop. More recently, technologies in machine learning, including induction, data mining, statistical and conceptual clustering, neural networks, and genetic algorithms have been added to the tools available for data analysis. Successful application of these technologies has ranged from bankruptcy analysis to mutual fund selection. These applications mine financial databases to discover relevant patterns for purposes of classification and prediction.

This paper illustrates how the application of knowledge based systems technology can benefit industrial sectors that consider strategic financial decisions on a regular basis. Such sectors may include banking institutions, pension companies, financial advisory institutions and in general any company that wishes to interpret another company's financial data. The objective of this paper is to show how knowledge based systems technology can assist in the interpretation of financial data for acquisition analysis. The authors discuss a prototype model designed to help a company formulate an effective acquisition decision. The model includes both rule based and case based reasoning technology. There is a particular focus on the issues involved in the application of case based reasoning techniques to the automation of the acquisition decision. The development of this system is intended to illustrate that a case based system is capable of providing sound solutions utilising relatively small case libraries, while avoiding a large rule base and long rule chains necessary for this domain if rule based reasoning was used exclusively. The model serves as a basis for discussion and a framework for future research.

2. THE ACQUISITION DECISION

The advantages and popularity of acquisitions as a policy for corporate development are well established [3]. In theory, the organisation decides its objectives and what acquisitions will be part of the strategy to achieve these objectives. It will then proceed to buy a company which meets the required criteria. Organisations such as Hanson and Trafalgar House that make acquisitions part of their corporate development continuously monitor companies that may be available for purchase which fit their organisations development strategy. There are many reasons why such an organisation may wish to acquire another. Some of the possible reasons are outlined below:

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Acquiring another company is a cost effect method of growing;
Strengthen the capital base of the organisation as a whole. This is effected by purchasing a company with a large fixed asset base that may be undervalued;
Increase market share and so gain a better competitive stance.
Eliminate a competitor;
Sell off the target company in parts in order to realise a profit on the transaction;
Gain access to a restricted market that has many controls;
Eliminate the dominant effect of a supplier, distributor or retailer by purchasing them;
Acquiring another company is seen as a defensive measure if a hostile take-over of the user's company is rumoured;
Hedging against Foreign Exchange exposure;
Acquiring another company in the same sector but with a large cash base and then using these reserves in price cutting to eliminate the competition in that area and to strengthen the long term prospects of the whole group of connected companies;
With the dismantling of the communist system in the Eastern European countries, many Western companies are evaluating companies in these countries for acquisition in order to get a foothold in these underdeveloped and potentially lucrative markets.

The analysis of the acquisition decision involves an investigation of both qualitative and quantitative criteria. Newton [4] proposes the following three qualitative factors for use in the analysis of the decision:

Security. Measure the security of the investment by examining its understanding of the activities of the organisation (buying, selling, manufacturing, organisation, etc.);
Industry Prospects. Concerned with an analysis of the state of the market for which the acquisition operates;
Company Prospects. Concerned with the competitiveness of the company within the industry, its market position, and its organisational and technological position.

Quantitative analysis stage focuses on potential company's financial statements. The objective of the model put forward in this paper is to determine the company which most closely meets the financial performance values set out by the company making the acquisition in their ideal company profile. Ratio analysis is

applied to the interpretation of this financial data.

3. RATIO ANALYSIS

The ability to interpret financial data in order to assist in making financial decisions is not straightforward. For example, some people see a profit increase as the best indicator of the success of a business. They may not consider the diminishing cash flow position, the increased obsolescence of fixed asset machinery or stock, or the increase in the bad debt provision. The profit may only be short term and other indicators about the future should be assessed. It is considered by the majority of financial advisors; that ratio analysis is the most appropriate method of analysing financial information and that the company's audited financial statements give the best and most meaningful financial data that should be used for interpretation purposes [5]. Though ratios are a vital financial tool they do have their limitations, some of which are outlined briefly as follows:

Indicative at best;
No truly objective measures available;
No consideration of non-qualitative and non-financial measures;
Rations calculated using Balance Sheet figures are static, as the Balance Sheet is only a snapshot of the company's financial position;
Sensitive to changes in accounting bases & policies;
Sensitive to 'window dressing' of accounts[1];
Industry Specific.

The ratios that will be used in this model can be divided into four different categories as follows: *profitability*, *liquidity*, *efficiency* and *financial strength and gearing*. Within each category a number of ratios have been chosen. It is considered by the authors that the ratios chosen offer the best information about that particular category. The ratios can be built into the model as different cases and can be used to search for similar cases within the case base of the relevant industry sector.

4. KNOWLEDGE BASED SYSTEMS

Knowledge Based Systems (KBS) software contains specialist or expert

1 The introduction of the financial Reporting Standard 5 (substance over form) should eliminate some of the current commonly used 'window dressing' techniques.

knowledge about how to solve a problem. They differ from conventional software because the knowledge is usually encoded using high level knowledge representation formalisms. These formalisms include rules, facts, objects, frames, cases, etc. The source knowledge for a KBS may come from an expert, manuals, on-line database, or all three in any combination. The prime advantage of using KBS technology is that knowledge that is important to an organisation's proper functioning has been captured and made available for the benefit of that organisation. The knowledge residing in workers in an organisation is often a vital asset, and retaining it gives the organisation the capability to grow rapidly, and to transfer skills and knowledge more easily. One of the main limitations of KBS is that they cannot learn easily from experience. Thus the knowledge may need to be reformulated and represented periodically as external forces and company changes modify the environment of the KBS. Case based reasoning partially addresses the learning issue.

Case Based Reasoning (CBR) is a subset of KBS. It is based upon work done in cognitive science and computer science communities [6]. In CBR, a new problem or situation case is compared with a library of stored cases: a case base. Using heuristically based indexed retrieval methods, the most relevant cases are made available to the user. At this stage, if the best retrieved case is a perfect match, then the system has achieved its goal, and finishes. However, it is more usual that the retrieved case matches the problem case only to a certain degree. In this situation, the closest case may provide, at worst, a sub-optimal solution; or the closest retrieved case may be adapted using some pre-defined adaptation formulae or rules. Adaption in CBR systems means that such systems have a rudimentary learning capability, which can improve (become more discriminatory) as the number of cases increases. In CBR systems, retrieval is based upon how the cases have been indexed. The most popular case-indexing techniques are nearest neighbour, inductive indexing and knowledge guided induction. Nearest neighbour retrieval (see Equation 1) works by retrieving cases based upon a comparison of a collection of weighted features in the problem case to the same features in the stored cases. Depending on the weight given to each feature, an aggregate match score is calculated [7].

Equation 1. Nearest Neigbour Similarity Function

where is the weight of feature *i*, *sim* is the similarity function, and and are the values for the features of the input and retrieved cases. The retrieved case with the highest aggregate match score represents the nearest match, and cases with a lower score are ranked beneath the highest scoring case. Inductive indexing uses clustering to generate a decision tree based upon the features of the cases in the case base that discriminate between various outcome values. Inductive clustering is most frequently employed when the case base is large and there is a requirement to consider only a subset of the total case base for efficiency reasons. These subsets are clusters that are discriminated by case feature values. Knowledge guided induction is similar to inductive indexing but imposes specific domain knowledge onto the generated decision tree, which reflects particular domain knowledge constraints.

5. THE IMPLEMENTATION OF THE SYSTEM

5.1. PROBLEM DEFINITION

The system is concerned with providing a company with a structure to follow in the acquisition decision-making process. It will address the following:

What are the interests of the company considering the acquisition? For example is the purpose to increase market share or obtain access to a particular market?
What issues need to be considered when analysing potential company's financial situation?
What qualitative factors should be considered when making the acquisition decision?

5.2. FEASIBILITY STUDY

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In order to determine if the acquisition decision is a suitable domain for a KBS application, and bearing in mind that the system would have a large CBR component, a checklist was constructed. The checklist provides three criteria of evaluation:

There should be existing cases available to the system developers;
An expert must be available who can describe the knowledge content present in each case;
If the knowledge is mostly formed as heuristics then use rules; if more exceptions than rules, then use cases.

The acquisitions model will require the application of both case based reasoning and rule based techniques. The acquisitions model, discussed in section 6, lends itself well to the application of case based reasoning. For example, when assessing the liquidity position of companies, the case library will consist of descriptions of the relevant liquidity ratios of each of the companies. The user of the system (the acquisitions team) will provide the heuristic knowledge necessary to revise the company's financial values in the case library that are most similar in terms of the performance values set out in the profile of the ideal company. Most of the system's knowledge based capabilities will make use of case-based technology. Retrieval using the nearest neighbour algorithm means that the retrieval process is non-brittle, and will obtain a sub-optimal solution, rather than none at all. The system will also contain components with rule based processing. The rules will manipulate the route taken by the system to reach a conclusion at each stage of the acquisitions model.

5.3. PERFORMANCE OBJECTIVES

The primary objective of the acquisition model is to provide a company wishing to acquire another, with a formal method for the identification and appraisal of various alternative companies that match the requirements that are input into the model. This is the high level requirement of the system which can be refined into the following objectives:

Address vital issues that should be considered when analysing the acquisition of target companies. This decision will be the subject of constraints imposed by the acquisition team based upon their discussions on the acquisition. An example of a constraint would be the fact that management may not wish to purchase a company in another country because of lack of knowledge on market conditions.

The model will allow the user to carry out a comprehensive appraisal of the factors that should be considered when consolidating with another company. These factors concentrate on the long term ramifications associated with a potential relationship with the target company.

Determine if the company's management are competent in business and are effective and efficient in the utilisation of the company's reserves; i.e., its assets.

Build up and maintain a data structure to store the vital information necessary for making an effective acquisition decision and have access to an on-line database detailing more information on the target company. This information can then be used within the case base for future decisions on similar companies. The information stored in this model may include share price, number of employees, a brief history of growth and profitability and three year financial statement summaries.

The interaction style in the system will be designed for use by a management team rather than one individual. The dialogue between the team and the system will be in the form of questions with various menu options to choose from.

The system will have a 'what-if' scenario analysis function that can examine the impact of changes in the data on the results. For example, the ratio values of the ideal company required could be adjusted to reflect different scenarios in order to analyse the effects these changes would have upon which companies are retrieved.

These clearly stated objectives are essential in order to facilitate an evaluation of the system. These performance objectives are a complete statement of the requirements of the system and provide a framework within which the system development can be controlled and evaluated after implementation.

5.4. THE PROTOTYPING APPROACH

A rapid prototyping approach to the development of the system was adopted. A prototype refers to a small-scale system. The advantages of a prototyping approach are as follows:

Involves representing the knowledge captured in a manner that enables quick

inference, and the creation of major components of the system on a rudimentary basis;
Enables the developer to decide quickly on the structure of the case base;
Accelerates the process of knowledge acquisition;
Provides a sound indication of the value of the development tools;
The design of the system can be evaluated initially. When design flaws were encountered they were more easily corrected at the prototyping stage.

When the knowledge engineering paradigm used is case based, the knowledge elicitation bottleneck problem is not so dominant. This is because the cases act as an excellent starting point for discussion of domain knowledge with an expert, and the discussion stays focused on the cases, as the case base is incrementally grown.

5.5. DEVELOPMENT TOOL SELECTION

The systems requirements dictated that the environment must be suitable for rapid application development, and be capable of combining different IT and KBS techniques into a hybrid system. The system must be PC based, and use an industry standard database to store findings and operational data. From these constraints, it was decided to use Visual Basic as the main development environment. This allowed rapid development of code, and the linking of external specialised libraries for use in the main program. In practice, these external libraries comprised a CBR library, ReMind, and some graphics code libraries. The system uses an MS Access database as a back-end data store.

It was felt that ReMind was the best tool for the case based retrieval function, as it employed the nearest neighbour algorithm that proved most suitable when retrieving cases where a large number of features (fields) had a numerical data type. However, it is known that the efficiency of this algorithm degrades exponentially as the number of features (fields) included increase. Therefore, other CBR libraries, for example, KATE [8] and ReCall [9], may be used if there is a requirement for efficiency.

6. DOMAIN ANALYSIS

The system is structured around the acquisition model as shown in Figure 1. The model represents the hierarchical nature of the decision making process. The initial impetus for an acquisition may come from the corporate level of the

organisation. The board of directors may decide to pursue an acquisition strategy for a number of reasons such as regional diversification, to eliminate competition, as a defensive measure, to gain access to cash, to increase market share, etc. When this decision has been made, it will then be the responsibility of the lower levels of management to seek and analyse potential companies that meet the needs of the acquiring company.

Figure 1. Acquisition Model

It is suggested that a team, from various parts of the business, should be formed to effectively carry out this analysis. An outline of the different stages in the model and how KBS is applied will now be presented.

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6.1. STAGE 1 - SET ACQUISITION CRITERIA AND OBJECTIVES

This stage is carried out by the corporate planning team and is broken down into the following steps :

1.- This step consists of identifying the following criteria for the acquisition: Country/Region, Industry Sector, Size and Net assets. This will allow the system to retrieve potential companies from the on-line database which meet these criteria.

2.- The system will provide a number of options outlining potential reasons for the acquisition For example, one of the options could be to strengthen the capital base of the acquiring company as a whole. Each purpose for the acquisition will have different implications for the business ratios used when retrieving the ideal companies in Stage 3.

6.2. STAGE 2 - PRELIMINARY IDENTIFICATION OF POTENTIAL COMPANIES

The system retrieves suitable companies that meet the group of criteria which include country/region, industry sector, size and net assets. The information on the companies retrieved will be restricted to those companies most similar to the declared target profile. It is intended that a form of case based retrieval, *knowledge-guided inductive retrieval*, is used in this part of the model. However, such research is beyond the scope of this paper, and will be incorporated into future publications.

6.3. STAGE 3 - ANALYSE POTENTIAL COMPANIES IN RELATION TO ACQUISITION OBJECTIVES

This stage is concerned with finding the companies retrieved in Stage 2 that most closely meet the ideal financial criteria set out in the acquisition objectives. It acts as a guide for eliminating those companies which are clearly unsuitable. The financial ratios under analysis are grouped into four categories: profitability, liquidity, efficiency and financial strength and gearing. Within each category ratios have been chosen that are considered to offer the best information about that particular category. The ratios chosen are detailed in Table 1.

Category	Ratios/Fields
Profitability	Gross Profit %, Net Profit %, Contribution Ratio %
Liquidity	Current Ratio, Acid Test Ratio, Stock Turnover Ratio, Debtors Ratio, Creditors Ratio
Efficiency	Return on Capital Employed, Net Asset Turnover, Fixed Asset Turnover, Wages Efficiency, Administration Expenses to Sales
Financial Strength and Gearing	Gearing, Interest to Sales %, Earnings per share, Dividend yield

Table 1. Categories of Ratios

The importance of each ratio category will differ depending upon the defined criteria and objective of the acquisition. It is assumed that the model user has knowledge in this area and can rank the different categories by giving each one a weighting value that represents that category's importance to the objective of the acquisition. For example, if the objective was to obtain a 'cash cow' company in order to increase market share and eliminate competition by using the 'cash cow' cash reserves to undertake a price cutting strategy, then the most important ratio category would be liquidity, followed by profitability, efficiency and then financial strength. When the ideal values required have been entered for each category, the system will then retrieve those companies which most closely meet these values. A total score is computed for each company across these categories. The weightings selected for each ratio category are applied to each category performance score for the potential companies. The system will filter out any unsuitable companies on the basis of the total score each company attained in the financial analysis. For example, the acceptance threshold set by the user may be 0.8. If any of the companies have a total score greater than this objective, then these sources shall be considered suitable for further analysis. Cases within the case library will consist of the relevant financial ratios of the companies retrieved from the on-line database in Stage 2. The weightings assigned to the case fields reflect the level of importance these fields have upon the acquisition decision. The structure and number of fields in each case may be customised to suit the requirements of any organisation in which the system is being implemented.

6.4. STAGE 4 - AN ANALYSIS OF THE ORGANISATION

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The objective of this stage is to determine the compatibility of the potential take-over company to the objectives of the acquiring company set out in Stage 1. Multi-Attribute Analysis (MAA) will be applied to the analysis of these categories. MAA is capable selecting or identifying optimum choice in respect of the same objectives where the decision alternatives are predetermined [10]. The advantages of MAA are primarily that it facilitates decision making despite the presence of multiple conflicting criteria. Hence it is suitable for the multi-criteria/multi-alternative nature of this stage, i.e., the evaluation and selection of a suitable company for acquisition. It is not within the scope of this paper to describe the application of MAA. This stage should identify the key variables which underpin profitability and future growth. The analysis will involve exclusively qualitative criteria broken down into the following three categories:

Security - Research over the years has revealed that acquisitions can be a potentially risky proposition [11]. Particular emphasis should be given to the need for the acquiring company to measure the security of its investment by examining its understanding of the activities of the acquisition. Possible factors for an analysis of the security of the acquisition may include possible physical limitations, possible social limitations, an understanding of company's activity within the industry and an understanding of the company's organisation.

Industry Prospects - Industry Prospects is concerned with the state of the market for which the acquisition operates. Possible factors for inclusion are as follows: rate of market growth, stability of profit margins and threat of substitutes. It is also necessary to consider the benefits to the organisation of lateral growth, vertical growth, and diversification, both through what the acquisition can give to the organisation and what the organisation can give to the acquisition.

Company Prospects - This is concerned with the specific features of the company being considered for acquisition. An important part this category is the competitiveness of the company within the industry, its market position and its organisational and technological position. Relevant factors in this analysis may include market share, relative profitability, product life cycle and distribution network.

Once the analysis is carried out for each category within the organisation analysis, a total organisation profile score is computed for each company. The calculation method for the total score is the same method as used in the calculation of the financial section total score. The system will filter out any companies who are unsuitable on the basis of the total score each company attains under the

organisation analysis.

6.5. STAGE 5 - ESTABLISH ACQUISITION PROGRAMME

Having identified a target company and established as much about it as possible from published and other third party sources, the next stage is establish an acquisition programme and do the deal. Key issues to be addressed are: organising for acquisition, making the approach, handling negotiations, valuation, managing currency risk if appropriate, management issues, handling industrial relations and necessary commitment [12].

This is not an exhaustive list of the factors involved in the analysis. However, it highlights and demonstrates the complexity and ramifications of making an effective acquisition. Each case will be different; but in every case considerable commitment is required by the acquiring company and a thorough analysis is necessary at each stage.

7. CONCLUSIONS & FURTHER ENHANCEMENTS

The development of this hybrid system has shown that it is possible to use knowledge based systems methods to build a hybrid decision support system in the area of financial strategic decision making, especially if the domain is well defined, has a large number of factors to be considered and the relevant knowledge is available. This system has illustrated the immense impact that knowledge based systems technology and case based reasoning in particular can have upon business processes. KBS have proved of value in scientific and medical applications and many commentators are predicting that they will prove equally valuable in business applications. The reasons are that many areas and applications rely on the expertise and knowledge of specialists, for example financial ratio analysis, in the same way that medical diagnosis relies on the expertise of specialists.

It is likely that the ability to use trend analysis over time will become crucial when attempting to analyse data in area of performance evaluation using ratios. Certainly this is what experts do, when they want to discover determinants of events, and / or trends in companies. The temporal aspects may simply be treated as another dimension, yet this approach may lose much of the semantic information encoded in trend lines. The authors hope to investigate if techniques that are used frequently in econometrics, such as co-integration, may be employed in conjunction with nearest neighbour retrieval and rule based processing to assist interpretators of financial statements in their strategic decision making.

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Clearly the prototype system outlined in this paper is a hybrid system. It uses rule and case based reasoning technology from KBS, statistical techniques such as multi-attribute analysis, with graphical and other components. The authors believe that this full hybrid approach, in this case where different components from different disciplines are brought together to provide a solution to the acquisition analysis decision model, offers synergistic benefits to the developer. These benefits include greater flexibility when developing the approach or model and resulting robustness in operation of the completed system. It is hoped that work will begin shortly to develop a framework for building full hybrid systems.

It is anticipated that the end user of this system would be someone in a financing company or banking institution/investing company such as a pension company who is responsible for making financial decisions based upon the interpretation of financial data using ratios. Another class of user is the consultant. In this mode of operation, the system could be used by an external consultant visiting client and suggesting advice based upon the retrieval engine and multi-attribute analysis components of the system. It is hoped that usability issues are addressed in a future version of the tool, and that field testing may be carried out to validate this role for the tool.

Data mining is proving to be a popular topic amongst IT and management professionals. Essentially data mining algorithms make possible the discovery of unknown patterns and structures in financial, medical, or manufacturing data. These algorithms could be used to reveal any heuristics or importance factors that could be embedded in the acquisition analysis system.

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Equation 1. Nearest Neigbour Similarity Function

Figure 1. Acquisition Model

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Category	Ratios/Fields
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Efficiency	Return on Capital Employed, Net Asset Turnover, Fixed Asset Turnover, Wages Efficiency, Administration Expenses to Sales
Financial Strength and Gearing	Gearing, Interest to Sales %, Earnings per share, Dividend yield

Table 1. Categories of Ratios